

Evaluation of B_4C as an Ablator Material for NIF Capsules

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NIF capsule design depends on a balance among what will properly implode and what can be properly built, and fielded, and diagnosed. All capsule designs will be made primarily from low Z materials (C or lower atomic number) with a few percent of oxygen or nitrogen allowable and a few percent of a higher Z material (e.g., Br or Cu) added for opacity control. A capsule using pure B_4C ablator material encasing a layer of solid DT can be imploded successfully using current anticipated NIF x-ray drives. It will achieve ignition and significant fuel burn, producing 18 MJ of energy with an x-ray drive having a peak radiation temperature of 300 eV. The B_4C both shields the DT fuel from preheat effects and develops an ablation front density profile favorable to stable implosion. Both effects are achieved with pure B_4C , i.e., no higher Z dopant is necessary as with CH/Br or Be/Cu capsules. Preliminary designs with pure boron did require a dopant, so this option was not pursued due to more difficult fabrication issues. B_4C is a semiconductor with a band-gap in the blue/UV region. Optical densities as a function of wavelength were measured for 0.15 to 2 μm films from the IR to UV and fitted to dispersion theories. The optical densities were unchanged after 6 months, indicating no significant oxidation. These results indicate that thin permeation barriers will allow optical characterization and possibly enhancement of DT ice layers, but full-thickness B_4C capsules could not use optical methods. Polystyrene mandrels 0.5 mm in diameter were successfully coated with 0.15-2.0 μm of B_4C . Thicknesses estimated from optical density agreed well with those measured by SEM. The B_4C microstructure was columnar but finer than for Be. B_4C is a very strong material, with a fiber tensile strengths capable of holding NIF fill pressures at room temperature, but it is also very brittle, and microscopic flaws or grain structure may limit the non-cryo fill pressure. Argon permeation rates were measured for a few capsules that had been further coated with 5 μm of plasma polymer. The B_4C coatings tended to crack under tensile load. Some shells filled slower than they leaked, indicating the cracks open and close under opposite pressure loading. The 0.15 μm coatings had leak half-lives up to 15 hours, and 2 μm coatings had half-lives up to 6 hours. Alternating thin B_4C and polymeric layers could likely reduce permeation far below that of current PVA technology, even if some cracks develop. Permeation and fill strength issues for capsules with a full ablator thickness of B_4C are unresolved.

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